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For: ROTARY FACE SEAL ASSEMBLY

1 Sub 1. A rotary seal assembly comprising:
2 A1 a first member having a sealing face; and
3 a second member having a sealing face with a number of pumping
4 grooves therein, at least a first set of pumping grooves starting proximate a center portion
5 of the sealing face and extending outward and at least a second set of pumping grooves
6 starting proximate the center portion of the sealing face and extending inward to direct
7 fluid fed to the center portion of the sealing face simultaneously both inwardly and
8 outwardly from the center portion of the sealing face to provide a uniform fluid film
9 thickness between the sealing faces of the first and second members when one sealing
10 face cones due to thermal and/or pressure effects.

1 2. The rotary seal assembly of claim 1 further including a feeding groove for
2 providing fluid to the center portion of the sealing face.

1 3. The rotary seal assembly of claim 2 in which the feeding groove is in the
2 first member.

1 4. The rotary seal assembly of claim 2 in which the feeding groove is in the
2 second member and positioned at the center portion of the sealing face thereof.

1 5. The rotary face seal assembly of claim 2 in which the feeding groove is
2 discontinuous forming a number of feeding groove sections.

Fig. 4

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1 6. The rotary face seal assembly of claim 5 in which each feeding groove
2 44 section has an orifice therein.

Fig. 12, 13, 16

1 7. The rotary face seal assembly of claim 6 in which the orifices are angled.

Fig. 7

1 8. The rotary face seal assembly of claim 2 in which the feeding groove is
2 continuous.

1 9. The rotary face seal assembly of claim 8 further including a number of
2 orifices in the continuous feeding groove.

1 10. The rotary face seal assembly of claim 9 in which the orifices are angled.

1 11. The rotary face seal assembly of claim 1 in which the first member is a
2 stator ring.

1 12. The rotary face seal assembly of claim 11 in which the second member is a
2 rotor ring.

1 13. The rotary face seal assembly of claim 1 in which the first member is a
2 rotor ring.

1 14. The rotary face seal assembly of claim 13 in which the second member is a
2 stator ring.

Sub A2
2 15. The rotary face seal assembly of claim 1 in which the first set of pumping
grooves each have a terminal end located inward of an outer portion of the sealing face.

1 16. The rotary face seal assembly of claim 1 in which the second set of
2 pumping grooves each have a terminal end located inward of an inner portion of the
3 sealing face.

1 17. The rotary face seal assembly of claim 1 in which the first set of pumping
2 grooves and the second set of pumping grooves start adjacent each other at the center
3 portion of the sealing face.

1 18. The rotary face seal assembly of claim 1 in which the starting position of
2 the first set of pumping grooves are offset from the starting position of the second set of
3 pumping grooves.

Sub A3
2 19. The rotary face seal assembly of claim 1 in which the first set of pumping
grooves curve outwardly from the center portion of the sealing face.

1 20. The rotary face seal assembly of claim 1 in which the second set of
2 pumping grooves curve inwardly from the center portion of the sealing face.

1 21. The rotary face seal assembly of claim 1 in which all the pumping grooves
2 have a width greatly exceeding their depth.

1 22. The rotary face seal assembly of claim 1 in which each pumping groove
2 has an inside edge and an outside edge, both edges curving inwardly.

1 23. The rotary face seal assembly of claim 1 in which each set of pumping
2 grooves includes the same number of pumping grooves.

1 24. The rotary face seal assembly of claim 2 in which the feeding groove has a
2 rounded bottom.

1 25. The rotary face seal assembly of claim 2 in which the feeding groove has a
2 square bottom.

1 26. The rotary face seal assembly of claim 1 further including a holder
2 mounted to one said member and movable therewith, and a spring which biases the first
3 and second members apart.

1 27. The rotary face seal assembly of claim 26 in which there is a gap between
2 the holder and the said member responsive to system pressure which overcomes the
3 spring at a predetermined level.

1 28. The rotary face seal assembly of claim 26 in which the holder includes a
2 shaft fixed thereto, the spring disposed about the shaft and abutting a non-movable
3 member.

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1 29. The rotary face seal assembly of claim 1 further including a holder for one
2 said member configured to allow said member to cone negatively when the other member
3 cones positively and allows said member to cone positively when the other member cones
4 negatively.

1 *AS* 30. A rotary seal assembly comprising:
2 a first member having a sealing face with feeding orifices therein;
3 and
4 a second member having a sealing face with a number of pumping
5 grooves therein, at least a first set of pumping grooves starting proximate a center portion
6 of the sealing face and extending outward and at least a second set of pumping grooves
7 starting proximate the center portion of the sealing face and extending inward to direct
8 fluid fed to the center portion of the sealing face of the second member by the feeding
9 orifices of the first member simultaneously both inwardly and outwardly from the center
10 portion of the sealing face of the second member to provide a uniform fluid film
11 thickness between the sealing faces of the first and second members when one sealing
12 face cones due to thermal and/or pressure effects.

1 31. The rotary face seal assembly of claim 30 in which the feeding orifices are
2 positioned in a discontinuous feeding groove in the first member forming a number of
3 feeding groove sections.

1 32. The rotary face seal assembly of claim 31 in which each feeding groove
2 section has an orifice extending through the thickness of the first member.

1 33. The rotary face seal assembly of claim 32 in which the orifices are angled.

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1 34. The rotary face seal assembly of claim 30 in which the orifices are
2 positioned in a continuous feeding groove formed in the first member.

1 35. The rotary face seal assembly of claim 34 in which the orifices are spaced
2 in the continuous feeding groove and extend through the thickness of the first member in
3 the continuous feeding groove.

1 36. The rotary face seal assembly of claim 35 in which the orifices are angled.

1 37. The rotary face seal assembly of claim 30 in which the first member is a
2 stator ring.

1 38. The rotary face seal assembly of claim 30 in which the second member is a
2 rotor ring.

1 39. The rotary face seal assembly of claim 30 in which the first member is a
2 rotor ring.

1 40. The rotary face seal assembly of claim 39 in which the second member is a
2 stator ring.

1 41. The rotary face seal assembly of claim 30 in which the first set of pumping
2 grooves each have a terminal end located inward of an outer portion of the sealing face of

3 the second member.

1 42. The rotary face seal assembly of claim 30 in which the second set of
2 pumping grooves each have a terminal end located inward of an inner portion of the
3 sealing face of the second member.

1 43. The rotary face seal assembly of claim 30 in which the first set of pumping
2 grooves and the second set of pumping grooves start adjacent each other at the center
3 portion of the sealing face of the second member.

1 44. The rotary face seal assembly of claim 30 in which the starting position of
2 the first set of pumping grooves are offset from the starting position of the second set of
3 pumping grooves.

1 45. The rotary face seal assembly of claim 30 in which the first set of pumping
2 grooves curve outwardly from the center portion of the sealing face of the second
3 member.

1 46. The rotary face seal assembly of claim 30 in which the second set of
2 pumping grooves curve inwardly from the center portion of the sealing face.

1 47. The rotary face seal assembly of claim 30 in which all the pumping
2 grooves have a width greatly exceeding their depth.

1 48. The rotary face seal assembly of claim 30 in which each pumping groove
2 has an inside edge and an outside edge, both edges curving inwardly.

1 49. The rotary face seal assembly of claim 30 in which each set of pumping
2 grooves includes the same number of pumping grooves.

1 50. The rotary face seal assembly of claim 31 in which the feeding groove
2 sections of the first member have rounded bottoms.

1 51. The rotary face seal assembly of claim 31 in which the feeding groove
2 sections of the first member have square bottoms.

1 52. The rotary face seal assembly of claim 30 further including a holder
2 mounted to whichever member is the stator and movable therewith, and a spring which
3 biases the first and second members apart.

1 53. The rotary face seal assembly of claim 52 in which there is a gap between
2 the holder and the stator member responsive to system pressure which overcomes the
3 spring at a predetermined level.

1 54. The rotary face seal assembly of claim 52 in which the holder includes a
2 shaft fixed thereto, the spring disposed about the shaft and abutting a non-movable
3 member.

15. The rotary face seal assembly of claim 30 further including a holder for
2 one said member configured to allow that member to cone negatively when the other
3 member cones positively and allows that member to cone positively when the other
4 member cones negatively.

56. A rotary face seal assembly comprising:

- a stator having a sealing face;
- a rotor having a sealing face in close proximity to the sealing face of the stator;
- a holder for the stator having a back seat which allows the stator to cone negatively when the rotor cones positively and vice versa;
- the sealing face of the rotor or the stator partitioned into at least first and second sections, the first section having pumping grooves which extend inwardly, the second section having pumping grooves which extend outwardly;
- the sealing face of the rotor or the stator having feeding orifices therethrough to direct fluid to the inwardly directed pumping grooves and the outwardly directed pumping grooves simultaneously thereby causing the stator to cone negatively when the rotor cones positively and vice versa.

57. The assembly of claim 56 in which the outwardly extending pumping grooves start proximate a center portion of the sealing face of the rotor or the stator and extend outward, and the inwardly extending pumping grooves start proximate the center portion of the sealing face of the rotor or the stator and extend inward to direct fluid fed to the center portion of the sealing face by the orifices simultaneously both inwardly and outwardly from the center portion of the sealing face.

58. The assembly of claim 56 in which the feeding orifices are disposed in a feeding groove formed in the face of the rotor or stator.

1 59. The rotary face seal assembly of claim 58 in which the feeding groove is
2 discontinuous forming a number of feeding groove sections.

1 60. The rotary face seal assembly of claim 59 in which each feeding groove
2 section has an orifice therein.

1 61. The rotary face seal assembly of claim 60 in which the orifices are angled.

1 62. The rotary face seal assembly of claim 58 in which the feeding groove is
2 continuous.

1 63. The rotary face seal assembly of claim 62 in which the orifices are spaced
2 in the continuous feeding groove.

1 64. The rotary face seal assembly of claim 63 in which the orifices are angled.

1 65. The rotary face seal assembly of claim 56 in which the stator sealing face
2 has the pumping grooves.

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66. The rotary face seal assembly of claim 56 in which the rotor ring sealing
face has the pumping grooves.

1 67. The rotary face seal assembly of claim 56 in which the rotor sealing face
2 has the orifices.

1 68. The rotary face seal assembly of claim 56 in which the stator sealing face
2 has the orifices.

1 69. The rotary face seal assembly of claim 56 in which the outwardly directed
2 pumping grooves each have a terminal end located inward of an outer portion of the
3 sealing face.

1 70. The rotary face seal assembly of claim 56 in which the inwardly directed
2 pumping grooves each have a terminal end located inward of an inner portion of the
3 sealing face

1 71. The rotary face seal assembly of claim 56 in which all the pumping
2 grooves start adjacent each other at the center portion of the sealing face.

1 72. The rotary face seal assembly of claim 56 in which the starting portion of
2 the pumping grooves are offset.

1 73. The rotary face seal assembly of claim 56 in which all the pumping
2 grooves have a width greatly exceeding their depth.

1 74. The rotary face seal assembly of claim 56 in which each pumping groove
2 has an inside edge and an outside edge, both edges curving inwardly.

1 75. The rotary face seal assembly of claim 56 in which each section includes
2 the same number of pumping grooves.

1 76. The rotary face seal assembly of claim 56 further including a spring which
2 biases the stator and the rotor apart.

1 *Sub A9* 77. The rotary face seal assembly of claim 76 in which there is a gap between
2 the holder and the stator member responsive to system pressure which overcomes the
3 spring at a predetermined level.

1 78. The rotary face seal assembly of claim 76 in which the holder includes a
2 shaft fixed thereto, the spring disposed about the shaft and abutting a non-movable
3 member.